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CHANGES IN THE FRESHWATER MUSSEL (MOLLUSCA: BIVALVIA) FAUNA OF THE CUYAHOGA RIVER, OHIO, SINCE LATE PREHISTORY

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ABSTRACT

We provide new information from archaeological samples on the historical freshwater mussel fauna (Mollusca: Bivalvia: Unionoidea) of the Cuyahoga River (South Park site: occupied between ca. A.D. 950 and 1650) and Black River (White Fort site, occupation centered at ca. A.D. 1350), northeast Ohio. Data from these prehistoric sites are compared with information on extant mussel populations of the Cuyahoga River published between 1890 and 2000. The high representation at both archaeological sites of the species *Actinonaias ligamentina*, *Elliptio dilatata*, and *Ptychobranchus fasciolaris* suggests that these were among the important clean water species in northeast Ohio prior to European settlement. By comparison, the modern mussel fauna of the lower Cuyahoga River (between Cleveland and Akron) contains none of these relatively abundant species, or any of the species represented in the archaeological material. The modern fauna of the lower river was established during the 20th century. This fauna is a low diversity assemblage of pollution tolerant species represented by rare live individuals. The modern mussel fauna of the upper Cuyahoga River (between Akron and the source) suggests that the upper and lower reaches are effectively isolated from each other. Published records indicate little change in the fauna during the last three quarters of the 20th century. Nevertheless, overall diversity, although substantially higher than that of the lower river, is considerably lower than that of the Grand River, which is located to the east of the Cuyahoga. Overall, the mussel fauna of the Cuyahoga River has changed greatly over time, most notably in terms of losses in diversity of clean water species and overall abundance.

Introduction

Freshwater mussels (Mollusca: Bivalvia: Unionoidea) are perhaps the most threatened group of animals in North America. Williams et al. (1993) reported that over 40 percent of the nearly 300 freshwater mussel taxa in the United States and Canada are considered extinct, endangered or threatened. Of the some 80 species that have occurred in Ohio, Watters (1996) reported that at least two-thirds are listed as extinct, extirpated, endangered, threatened, or of "special concern." This decline in species diversity followed at least 6000 years of stability preceding the diminution of eastern U.S. forests by European settlers (Bogan, 1990).

This study describes the changes that have taken place in the freshwater mussel composition (Family Unionidae) of the Cuyahoga River (Figure 1). The Cuyahoga River arises about 30 miles east of Cleveland, Ohio. It flows southwestward toward Akron and then describes a "U" as it turns to the northwest and empties into Lake Erie at Cleveland Harbor. The river is approximately 100 miles long. The section above Akron, which includes the source, is referred to as the "upper" part of the river. The section between Akron and the river's mouth is referred to as the "lower" Cuyahoga. The Cuyahoga River has been of critical importance to the history and economic development of Cleveland and northeast Ohio (Rose, 1950, p. 26, 69, 89, and 116, for example).

The extant freshwater mussels of the Cuyahoga River have been described scientifically beginning with Dean (1890). The most recent study has been by Smith (2000), who focused on mussel occurrence in the lower river within the Cuyahoga Valley National Park (formerly the Cuyahoga Valley National Recreation Area).

In this paper, we provide new information from archaeological specimens on the historical freshwater mussel fauna of the Cuyahoga River. Archaeological mussel data from the Black River, Lorain County, Ohio, are provided for comparison. Data from these prehistoric sites are then correlated with information from the literature on extant populations published between 1890 and 2000. Previous studies from other areas that have compared recent mussel distribution and ecology with archaeological data have been successful in reconstructing aquatic paleoenvironments and inferring environmental changes through time (e.g., Morey and Crothers, 1998; Hughes and Parmalee, 1999).

This study provides a view of the pre-European settlement mussel fauna of the relatively pristine Cuyahoga River. By comparing this fauna with the ones that followed, it is possible to see the multifarious effects of settlement and associated land use on an important component of the river's ecosystem. Also, knowing the fauna of the relatively pristine river provides information of potential use if the relatively stressed river of today is ever sufficiently restored to allow the re-introduction of the historical clean water species. Finally, bringing together the new and previously published data sets provides a longitudinal view of mussel populations that is unique not only for the Cuyahoga River, but also for all of northeast Ohio.

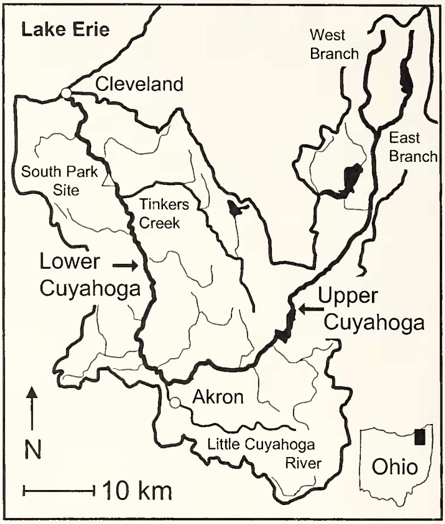

Figure 1. Cuyahoga River watershed and the location of the South Park collection site.

Materials and Methods

Archaeological contexts of identified bivalve samples

All the bivalve specimens examined for this study were selected from archaeological samples recovered from the South Park site (33Cu8; 41°22′43.80″ N, 81°37′20.97″ W) and the White Fort site (33Ln3; 41°24′53.28″ N, 82°6′30.42″ W). The South Park site is located on an isolated upland ridge spur (elevation of 220 m a.s.l.) that extends northwestward into the valley of the lower Cuyahoga River in Independence, Ohio. The White Fort site is located on a flat, sandy bluff (elevation of 207 m a.s.l.) that overlooks the Black River Valley in northern Elyria Township, Lorain County, Ohio. Extensive archaeological excavations under the direction of David S. Brose (Case Western Reserve University and The Cleveland Museum of Natural History) were carried out at the South Park site between 1968 and 1981 (Brose, 1994). The White Fort site was investigated from 1995 to 1998 by one of us (Redmond, 1999). Both sites are believed to represent semi-permanent, maize-agricultural village settlements. The major archaeological components at both the South Park and White Fort sites fall within the Late Prehistoric period, but South Park is affiliated with the Whittlesey cultural tradition (Brose 1994, p. 30–31), and White Fort with the Sandusky tradition

Table 1. Associated radiocarbon determinations of archeological specimens.

Lab. no.	Conventional age	Calendrical date	Calibrated intercepts	Calibrations (Vogel et al., 1993) 1 sigma	2 sigma
SOUTH PARK					
WIS 537 (Fea. 1)	310 ± 50 BP	A.D. 1640	A.D. 1638	A.D. 1495 to 1653	A.D. 1449 to 1952
CWRU 4 (Fea. 4)	305 ± 55 BP	A.D. 1645	A.D. 1640	A.D. 1495 to 1656	A.D. 1447 to 1953
WIS 538 (Fea. 49)	380 ± 55 BP	A.D. 1570	A.D. 1489	A.D. 1443 to 1633	A.D. 1429 to 1650
WHITE FORT					
Beta 90565 (Fea. 95-10)	670 ± 50 BP	A.D. 1280	A.D. 1300	A.D. 1285 to 1315& A.D. 1345 to 1390	A.D. 1270 to 1405
Beta 110713 (Fea. 95-10)	600 ± 50 BP	A.D. 1350	A.D. 1395	A.D. 1305 to 1410	A.D. 1290 to 1425
Beta 110714 (Fea. 95-10)	600 ± 40 BP	A.D. 1350	A.D. 1395	A.D. 1310 to 1365& A.D. 1375 to 1410	A.D. 1295 to 1420
Beta 90566 (Fea. 95-16)	370 ± 50 BP	A.D. 1580	A.D. 1495	A.D. 1455 to 1535 & A.D. 1545 to 1635	A.D. 1435 to 1650

(Stothers et al., 1994). According to Brose (1994), the South Park site provides evidence for as many as three temporally sequential village occupations that occurred between approximately A.D. 950 and 1650. Bivalve specimens were recovered from each of these cultural levels. In contrast, temporally sensitive archaeological remains from the White Fort site indicate a single major village occupation centered at ca. AD 1350 (Redmond, 1999, p. 141).

The bivalve specimens identified in this study were recovered from archaeological deposits that consisted of food residues and broken tools, ornaments, and other implements that were discarded by the village inhabitants. At both the South Park and White Fort sites such material was most often deposited into empty pits previously used for food storage or cooking. In a few cases, shell and other debris were discarded onto surface dumps (midden features) or into shallow trenches that originally served as foundations for the walls of oval- to circular-shaped dwellings. Regardless of context, all but one of the identified bivalve specimens are culturally unmodified and thus most likely represent the remains of freshwater mussels that were gathered and consumed by the inhabitants of eaeh village site. One specimen from the South Park site, identified as *Actinonaias ligamentina carinata* (CMNH Archaeology Collection 5948), exhibits a one centimeter-wide perforation which indicates that the shell was originally modified to tie a handle so that the shell could be used as a spoon, hoe, or other kind of implement.

Identified bivalve specimens were recovered from radiocarbon dated contexts at both the South Park and White Fort sites (Table 1). In the South Park site sample, shell fragments from Features 1 and 4 (pit features) were associated with wood charcoal that produced uncalibrated radiocarbon dates of A.D. 1640 ± 50 and A.D. 1645 ± 55 respectively (Brose, 1994, p. 171; 168). Charcoal from Feature 49 (pit feature) resulted in an uncalibrated date of A.D. 1570 ± 55 (Brose, 1994, p. 171). Bivalve samples from the White Fort site were recovered from two dated contexts. Feature 95-10 (a structural trench) contained abundant shells in association with charcoal samples that produced uncalibrated dates of A.D. 1280 ± 50, A.D. 1350 ± 40, and A.D. 1350 ± 50 (Redmond, 1999, p. 141). Charcoal from Feature 95-16 (pit feature) resulted in an uncalibrated date of A.D. 1580 ± 50 (Redmond, 1999, p. 141).

Both the uncalibrated and calibrated radiocarbon results derived from the South Park features and Feature 95-10 at White Fort support the proposed temporal spans for each site's occupation. The uncalibrated late sixteenth century date from White Fort Feature 95-16 appears to be too recent in age when compared to associated ceramic temporal indicators; however, it may date an as-yet unrecognized Late Prehistoric period occupation of the village site (Redmond, 1999).

Sample selection

All bivalve specimens observed in the South Park site and White Fort site collections represented either single valves or fragments of single valves. No articulated specimens were discovered, and all specimens were devoid of periostracum. Mussel shells were chosen for study based on their preservational state. Generally, at least 40 percent of the valve needed to be present to provide enough material for identification to the species level. All of the mussels from both collections belonged to the family Unionidae and were identified by reference to Watters (1995).

Results and Discussion

Table 2 summarizes the results of this study. The new data on archaeological specimens from the White Fort site and South Park site are summarized to the left in the table. Results of surveys of extant mussels are summarized to the right of these in chronological order, beginning with the findings of Dean (1890) and then Ortmann (1924). The "upper Cuyahoga" occurrences combine the results of Huehner (1985), Hoggarth (1990), and Huehner and Gyulai (1999). The "lower Cuyahoga" occurrences are from Smith (2000) and Smith et al. (2002); Tinkers Creek occurrences are from Krebs et al. (2002).

Together, these data show that the distribution, abundance and species composition of mussels in the Cuyahoga River have changed extensively since European colonization of the watershed. The seven sets of survey data in Table 2 highlight the substantial loss of species in the lower portion of the Cuyahoga, while the upper, less industrially impacted reaches of the river have changed little in the last 100 years.

Based on archaeological data from the South Park site, a diverse mussel community existed that may have been dominated by five species: *A. ligamentina carinata, Amblema plicata, Elliptio dilatata, Ligumia recta,* and *Ptychobranchus fasciolaris*. All of these latter species produce large, robust shells that should preserve well, and Watters (1995) describes each as generally abundant within the habitats where they are found. Eight additional species were less frequently encountered in the collections. All of these species are either rare in Ohio today, or possess small or fragile shells (Morey and Crothers, 1998). Two of these 13 species (*A. plicata* and *P. fasciolaris)* had apparently disappeared by the late 1800s, when Dean (1890) surveyed the river, although eroded shells of the former species still occur in the river today. Likewise, Morey and Crothers (1998) describe shells of four additional species not found in the archaeological material but present in the modern surveys (*Lampsilis fasciola*, *Lasmigona costata*, *Potamilus alatus*, and *Strophitus undulatus*) as sufficiently fragile to make under-representation in collections of ancient material a likely possibility. Nevertheless, an historical abundance likely explains why old, eroded shells of four of the five more commonly found species are still found as eroded shells in the Cuyahoga River (Smith, 2000; Smith et al., 2002).

The overall taxonomic similarity of the South Park and White Fort samples suggest that these collections provide important clues to the list of mussel species characteristic of northeastern Ohio rivers at a time prior to European settlement. The high representation at both archaeological sites of the species *A. ligamentina carinata*, *E. dilatata*, and *P. fasciolaris* suggests that these were among the more important clean water species, both ecologically and as a food resource, during late prehistory.

The modern composition of the lower Cuyahoga has changed greatly over time, and may contain as few as six species. In addition, because extensive survey work turned up only four live specimens and few fresh shells, it is also safe to conclude that mussels are rare in the lower Cuyahoga today. The live specimens which have been found are of the following three species: *Potamilus alatus*, *Pyganodon grandis*, and *Quadrula quadrula* (Smith, 2000; Smith et al., 2002). Of these, only *Potamilus alatus* was found by Dean (1890). *Pyganodon grandis* was previously reported only from the upper Cuyahoga (Ortmann, 1924) and *Q. quadrula* had not been reported before the work of Smith (2000) and Smith et al. (2002), although both species existed in Lake Erie prior to the introduction of zebra mussels (Ortmann, 1919).

Other species that may exist in the lower Cuyahoga include *Fusconaia flava*, *Lasmigona compressa*, and *Leptodea fragilis*, for which fresh shells were found (Smith, 2000; Smith et al., 2002). As is the case for *Q. quadrula*, the latter of these three species was also a new record for the Cuyahoga. *Fusconaia flava* was a common species in the last century and it is one of the few small species represented in the archaeological data, which may be biased towards larger species because the mussels were collected for food. Although *F. flava* has never become established in the upper Cuyahoga, this species is common today in Tinkers Creek, which may have provided a refuge when the river became polluted. Alternatively, Metcalf-Smith et al. (2000) describe *F. flava*, *P. grandis*, *P. alatus*, and *Q. quadrula* as possibly the most pollution tolerant of species living in the Grand River (Southwestern Ontario).

In contrast to the lower Cuyahoga, the unionid fauna of the upper part of the Cuyahoga River has changed little. Ortmann (1924) reported finding *Anodontoides ferussacianus*, *Lampsilis radiata luteola*, *Lasmigona costata*, *Lasmigona compressa*, *Ligumia nasuta*, *P. grandis* (not found by Dean, 1890), *S. undulatus*, and *Utterbackia imbecillis*. All of these species remain in the upper river (Huehner, 1985; Hoggarth, 1990; Huehner and Gyulai, 1999), and added to them is the now common *Lasmigona complanata*, which Dean (1890) found in the local canals. The stability of this community suggests effective isolation of the upper from the lower river. These eight species suggest good diversity, but the Grand River (Lake Co., Ohio), long considered one of the cleanest of the rivers in northeast Ohio, contained 17 species in the early 1900s (Ortmann, 1924).

This geographical isolation of populations also applies to the mussel communities of Tinkers Creek, a smaller stream, which, while not as heavily influenced by industry, slowly winds through agricultural and more suburban communities as it passes through the Twinsburg and Brecksville areas. Five species are common in Tinkers Creek (Table 2) and fresh shells of three others occur occasionally. The greatest contrast between the Cuyahoga River and Tinkers Creek is the presence of *F. flava* and possibly *Alasmidonta marginata* (three fresh shells) in Tinkers Creek. The biota of this tributary is clearly related to the lower Cuyahoga of the late 1800s and not to the fauna of the relatively pristine upper river.

Table 2. Historical distribution and abundance of unionid mussels in the Cuyahoga River watershed. Most species names are used in the sense of Watters (1995). Shell size indicates the largest expected size for Ohio forms (Watters, 1995). Old specimens are those showing extensive wear to the shells and complete loss of the periostracum. Data for the extant populations derive from Huehner (1985), Hoggarth (1990), Huehner and Gyulai (1999), Smith (2000), and Krebs et al. (2002).

Species	Shell size max. diam. (cm)	Black R. (White Fort) prehistoric shells	Cuyahoga R. (South Park) prehistoric shells	Cuyahoga (Dean, 1890)	Upper Cuyahoga (Ortmann, 1924)	Upper Cuyahoga shells	Upper Cuyahoga live mussels	Lower Cuyahoga shells	Lower Cuyahoga live mussels	Tinkers Creek shells	Tinkers Creek live mussels
Actinonaias ligamentina carinata	15	7	40	present				29 old		2 old	
Alasmidonta marginata	10			present						3	
Amblema plicata	15	1	45					11 old			
Anodontoides ferussacianus	10			present	present	2	11				
*Cyclonaias tuberculata**	12		1								
Elliptio dilatata	12	13	50	present				3 old			
Fusconaia flava	10		2	common				7		16	12
Lampsilis cardium	15	20	2	present				1 old			
Lampsilis fasciola[1]*	10			present							
Lampsilis radiata luteola	12	1	2	present	present	116	334			31	1
Lasmigona complanata	15			canal		110	274				
Lasmigona compressa	10			present	present	15	33	1		11	11
Lasmigona costata[1]	12	1		present	present	26	63	3 old		13	17
Leptodea fragilis	15							3			
*Ligumia nasuta***	10			present	present	51	87				
*Ligumia recta**	25	2	15	present							
Obovaria subrotunda	7	3	5	present							
*Pleurobema sintoxia**	12		6	present				1 old			
Potamilus alatus[1]	20			present				1	2		
Ptychobranchus fasciolaris	15	48	23								
Pyganodon grandis	15				present	530	1171	3	1	153	77
Quadrula quadrula	10								1		
Strophitus undulatus[1]	10			present	present	14	38			5	
Toxolasma parvus	4	1		reservoirs						2	
Utterbackia imbecillis	10				present	3	9				
Villosa iris	7			present							
Total specimens		97	191	NA	NA	867	2020	15	4	234	118

[1] Identifies fragile shells, which may therefore be underrepresented in the midden analysis (Morey and Crothers, 1998).

* Special concern and threatened species

** Ohio endangered species

Conclusions

The similarities between the species lists compiled for the White Fort and South Park sites provide clues to the mussel fauna that inhabited the relatively pristine rivers of northeast Ohio prior to European settlement. The high representation at both archaeological sites of the species *A. ligamentina carinata*, *E. dilatata*, and *P. fasciolaris*, in addition to the large number of *A. plicata* at the South Park site, suggests that these were among the important clean water species in northeast Ohio prior to European settlement. The presence of their shells today verifies past abundance of at least three of the four species. Live specimens of *A. ligamentina carinata* and *E. dilatata* have not been reported since collections by Dean (1890), while by contrast, *A. plicata* and *P. fasciolaris* must have disappeared prior to the industrialization of the Cuyahoga River valley. Therefore, *A. ligamentina carinata* and *E. dilatata* are particularly good candidates for reintroduction into northeast Ohio streams once these streams have been restored to a cleaner condition. The modern fauna of the lower river was established during the 20th century and may be characterized as a relatively low diversity assemblage of pollution tolerant species represented by a low number of individuals. The modern Tinkers Creek fauna, by comparison, is possibly a "refugium fauna" of species characteristic of the lower Cuyahoga in the late 19th century.

The modern mussel fauna of the upper Cuyahoga clearly tells a tale of two rivers, where the upper and lower reaches are effectively isolated from each other. Published records indicate little change in the fauna during the last three quarters of the 20th century. Nevertheless, overall diversity, although substantially higher than that of the lower river, is considerably lower than that of the Grand River (Lake Co., Ohio). Moreover, it does not resemble the fauna reflected in the archaeological samples.

Overall, the mussel fauna of the Cuyahoga River has changed greatly since late prehistory, most notably in terms of losses in diversity of clean water species and overall abundance.

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